

## Differential emergence of representational systems: Drawings, letters, and numerals

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**Differential Emergence of Representational Systems:  
Drawings, Letters, and Numerals**

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### **Abstract**

This study investigated the process by which the representational activity and knowledge about drawing and letter and number writing emerge in children 21-46 months old. The results revealed that representational activities developed with age through several phases. Beginning at age 2, children produced different marks for different systems, but children under 2 produced common graphic marks. Representational systems were significantly correlated with developmental processes, but drawing developed faster than letters or numbers with respect to both their production and their classification. Three-year-old children were able to recognize each system correctly in a sample-matching task, but the recognition of each system was not correlated with representational activity. These findings indicate that only after children engaged in graphic production did they begin to make representational distinctions among systems by drawing on their domain-specific knowledge, although alternative explanations can be suggested.

**Keywords:** Drawing; Writing; Developmental process; Differentiation of system; Children 21-46 months old.

Although many researchers have investigated separately the development of various representational systems, such as letters, numbers, drawings, musical notes, and maps, recent studies have focused on the relationships and distinctions among representational systems as domains of knowledge (Brenneman, Massey, Machado & Gelman, 1996; Karmiloff-Smith, 1992; Tolchinsky-Landsmann & Karmiloff-Smith, 1992, et al.). In these studies, researchers have argued that each representational system develops on the basis of early domain-specific knowledge, and they have challenged the traditional views proposed by Piaget (1951) or Vygotsky (1978). For example, Tolchinsky-Landsmann and Karmiloff-Smith (1992) revealed, using sorting tasks, that children could discriminate writing and number notation from drawing according to the domain-specific constraints operating on each system. Brenneman et al. (1996) found that children's action plans differ for writing and drawing, by analyzing children's videotaped action sequences to determine their procedural competence. They concluded that action plans are constrained by a child's implicit domain-specific knowledge about words and objects.

Further studies of representational systems have been conducted from other perspectives or in more detail. Some researchers have investigated differences between writing and drawing from the viewpoint of production kinematics (Adi-Japha & Freeman, 2001). Others have explored this issue from the viewpoints of different languages or the understanding of pictures (Akita & Koike, 2000; Bialystok & Martin, 2003; Chan & Nunes, 1998, 2001; Komori & Takahashi, 2003; Levin, Korat & Amsterdamer, 1996; Saito, 1997; Thomas, Nye, Rowley & Robinson, 2001). However, all the studies described above have been restricted to drawing and writing in children of approximately 4 years and older, although Levin and Bus (2003) recently reported a study of younger children and Karmiloff-Smith (1992) and Ferreiro (1986) studied toddlers. Nevertheless, little is known about how children under 4 develop the representational systems of writing and drawing. Therefore, this study focused on very young children to investigate how these representational systems emerge, from the perspective of their domains of knowledge.

With regard to the emergence of representational systems, some studies report that even preliterate children often produce different marks when they write and draw (Brenneman et. al., 1996; Gombert & Fayol, 1992; Tolchinsky-Landsmann, 2003, et al.). Specifically, whereas children use short, discrete, and linearly ordered strokes for writing, they use more continuous curves, bounded marks and referential color for drawing. Even if the children do not know how to produce drawing and writing conventionally, these studies indicate that they produce different marks on the basis of the formal-perceptual features of each system and are able to distinguish between systems. Although the

evidence was mainly derived from children over 4 years old, these observations have been explained as being imposed by the constraints of early domain-specific knowledge.

On the other hand, Levin and Bus (2003) analyzed the drawing and writing of children 28-53 months old to explore the roots of their differentiated representational systems, using tasks in which the children were asked to draw and write the same eight referents, in addition to writing their name. They found that children up to age 3 draw and write indistinguishably by making scribbles or producing a good figure such as a square or circle-like form, and they asserted that drawing and writing emerge from a common core of indistinguishable, nonrepresentational graphic products. Thus, the studies to date have reached discrepant conclusions about when representational systems are differentiated, that is, whether representational systems are differentiated from the beginning or during later development.

Therefore, in this study, we sought to examine the processes by which representational systems emerge in Japanese children 21-46 months old and to elucidate the relationships and distinctions between drawing and writing. To meet these aims, very young children were given two tasks for drawing and writing: a production (P) task and a sample-matching (S-M) task. The P task was used to examine the marks children created with regard to the nature of the representational activity and the formal-perceptual aspects of domain-specific knowledge, and the S-M task was used to investigate the children's ability to recognize the same systems as sample stimuli. In the P task, we examined children's drawing and their writing of hiragana letters (a Japanese letter system) and numbers. We asked the children to draw their mother or father as the drawing task and to produce the numeral one and their name as writing tasks. Although these tasks deal with very limited and particular aspects of drawing and writing, we used such simple and easy tasks because we focused on very young children, as young as 1.5 years old. Moreover, these tasks not only represent the first conventional products made by very young children, but they are also meaningful activities for them. In the P task, we explored the distinction between systems by analyzing the marks produced by children. On the other hand, in the S-M task, we assumed that if the children could recognize a stimulus card as belonging to a system, they might have some understanding about that system, even if they didn't know its representational nature or the method used to represent it. The S-M task was used in this study because it is difficult for very young children to give meaningful answers when they are asked directly about how and what a system represents.

With regard to the development of drawing and writing, research has shown that most children produce human figural drawings as their first representational drawing at

about 3 years; the criteria are whether there is a contour of a head with a face consisting of eyes, mouth, and other features and whether the drawing can be recognized by others as a human figure (Yamagata, 1997, 2001). On the other hand, Japanese children begin to write basic hiragana letters after 4 years and often write their name as the first product (Amano, 1986; Muto, Misawa-Endo, Sakata & Takeshige, 1992; Shimamura & Mikami, 1994). Although researchers point out that name writing is a particular case of writing (Ferreiro, 1986; Muto et. al., 1992; Welsch, Sullivan & Justice, 2003), we asked the children to write their names using hiragana letters because they were so young. Generally, Japanese children acquire hiragana letters first among the three letter systems used in Japan (hiragana, katakana, and Chinese characters, i.e. kanji). The hiragana letters are syllabic characters and basic kana letters consisting of five vowels, a nasal coda and forty unvoiced CV (consonant-vowel) combinations. Japanese children can read 14.0 or write 3.7 (mean numbers of letters) of the forty-six basic hiragana letters at 4 years old (Shimamura et. al., 1994). Akita and Hatano (1999) reported a full account of children's acquisition of Japanese orthographies. Thus, we expect from previous studies that drawing should develop faster than writing.

In contrast, with regard to name and number writing, it is difficult to assess their relative difficulty, because while there are several studies of name writing (Bloodgood, 1999; Ferreiro, 1986; Shibasaki, 1987; Welsch et. al., 2003), there are no systematic studies of number writing by very young children. Researchers have investigated numerical concepts and knowledge (Gelman & Gallistel, 1978; Piaget, 1952; Strauss & Curtis, 1984; Wynn, 1992 et al.), but there have only been a few studies on the development of number production in young children (Munn, 1994; Sinclair, Siegrist & Sinclair, 1983). In addition, we have no systematic data on number writing by children less than 3 years old. However, Tolchinsky-Landsmann (2003) stated that the use of conventional numerals appears earlier and more frequently in comparison with the use of conventional letters at age 4~6 (p.158). Furthermore, when we compare letter and number writing using a limited set of elements, it is expected that producing numerals would be easier than writing a name because numbers are composed of fewer different elements (ten) than are the basic hiragana letters. Accordingly, we expect to obtain a different developmental rate for the products of these systems, that is, first drawing, then writing numerals, and finally writing hiragana letters.

When we compare different systems, we must nevertheless be careful about what criteria we use. In this study, even though it may be open to argument, we used as comparable criteria the conventional products created first by children in their development and recognized by others. In sum, this study investigated the processes by

which both the representational activity and the knowledge of drawing and writing letters or numerals emerge in very young children. The main purpose of our study was to elucidate the relationships and distinctions among these systems to examine the roots of their differentiation.

## Method

**Participants** Sixty-six children (37 boys and 29 girls; 1 year 9 months to 3 years 10 months) of middle-class background at a day-care center participated. They were divided into five age groups: 1.5 years ( $n = 9$ ,  $M = 1$  year 10 months, 5 boys, 4 girls), 2 years ( $n = 15$ ,  $M = 2$  years 3 months, 11 boys, 4 girls), 2.5 years ( $n = 14$ ,  $M = 2$  years 8 months, 8 boys, 6 girls), 3 years ( $n = 14$ ,  $M = 3$  years 2 months, 6 boys, 8 girls), and 3.5 years ( $n = 14$ ,  $M = 3$  years 7 months, 7 boys, 7 girls). We excluded the data from five children who could not concentrate on our tasks and became nervous. Of the children in the 1.5-year-old group, we analyzed only the data from five children in the P task, because only one of them could finish the S-M task and four children did not produce any writing.

**Tasks** Each participant was given two kinds of tasks: a S-M task and a P task. For the S-M task, we prepared four different lists of stimuli consisting of seven cards each. The number of cards in the lists was decided based on the children's age and the method used in previous studies (Tolchinsky-Landsmann et al., 1992; Saito, 1997). Each list of stimuli consisted of two hiragana word cards, two number cards, two picture cards, and a symbol card. Examples of the stimuli lists are presented in Table 1. Each card had a three-letter word, a three-digit number, three pictures, or three symbols, printed horizontally in black ink on white cards ( $13 \times 9$  cm). The pictures were flowers, birds, ships, and others. The symbols were used as distracters. Different lists of stimuli were given three times in counterbalanced order across participants. In the P tasks, we asked the participants to draw a human figure as the drawing task, and then to write their name in hiragana letters and produce the numeral 1. Because it is difficult for very young children to perform a large number of tasks, we gave them only three simple P tasks.

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Insert Table 1 about here.

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**Procedure** All the participants were tested individually in a separate room at their day-care center. They sat next to an experimenter at a table, and there was a stuffed bear on the table. In the S-M task, participants were first shown three different sample cards containing a hiragana letters, a number, and a set of pictures once, and then the

experimenter told them the notational names of these sample cards, for example, “This is a hiragana letters (or a number or picture)”. These sample cards were not included in the lists of seven stimuli described above. Next, the experimenter gave the children three S-M tasks in a counterbalanced order: picture, number, and hiragana letters. In each S-M task, the experimenter first put seven stimulus cards randomly on the table and then showed the children one of the three sample cards. The stimulus cards were presented randomly at the table each time with each child. After this, the experimenter asked the children to choose the same cards as the sample card. The following instruction was used: “Choose the same cards as this card (or the cards that are friends with this card) in order to teach the bear, please”. If children did not choose a card, they were encouraged to choose any card. They were permitted to choose as many cards as they wished, but most of them chose only one or two cards.

After the S-M task, the children were given a sheet of paper (size B4) and crayons, and were asked to draw a human figure. After drawing, they were asked to produce their name and then the number 1 on the same sheet of paper. The following instruction for the number was used: after the experimenter asked the child his or her age, she said, “Write down the number 1 on this paper, please.” If the children said that they could not produce it, they were encouraged to try. Generally, after Japanese children finish a drawing, they are taught to write their name on the edge of the same sheet. Moreover, they often learn numbers through an understanding of their age, although there are other opportunities to understand numbers. Therefore, we used this procedure so that our instruction would be easy to understand by very young children. After the two tasks, we examined the children’s ability to name basic hiragana letters (46 letters) and Arabic numerals (1 to 10). The experimenter gave the children pieces of paper on which hiragana letters and Arabic numerals were written in order, and asked the children to name as many as they could. We used this method because most of our participants could not yet read all the hiragana letters and numerals.

**Data analyses** In the S-M task, we recorded the cards the children chose and analyzed their responses. In the P tasks, we analyzed the children’s products by (1) classifying them generally into drawing or writing, and (2) coding them using the systems stated below. The classification was performed independently by two judges. We did not give the judges any information about these products, and we presented them in random order. They first classified the products into drawing or writing (numbers or letters). After that, they scored the products created by the children according to coding systems that we adapted from that of Levin and Bus (2003) to suit our data for very young children.

The coding systems are described in Table 2. In the coding of drawings, the products



were assigned to one of five categories. Categories 1 and 2 are considered to be graphic production, 3 and 4 to be drawings of humanlike figures, and 5 to be the conventional production of a human face. The name writing was divided into eight categories, using the revised coding system of Levin and Bus. The number products were also divided into eight categories. Among these categories, those related to segmentation are common to both name and number writing, but the linearity of units is only applicable to name writing and verticality only to numerals. In name and number writing, categories 1 and 2 are considered to be graphic production, 3~7 are letter-like or number-like production, and 8 is the conventional production, similar to the 5th category for drawing. Examples of these products are shown in Figure 1a and 1b. We assigned a 1 to 5- or 1 to 8-point score to each drawing and piece of letter or number writing according to the categories described above. We then combined these categories into three categories (representational phases) that were common among the systems (graphic production, pseudo-production, conventional production) so that all three systems could be analyzed in the same manner. Levin and Bus also proposed these three categories as general schemes.

***Inter-judge agreement*** The data were scored independently by two coders who were undergraduate students blind to the purpose of the study. Inter-judge agreement for the measurements was expressed as the percent agreement (the number of agreements divided by the sum of the agreements and disagreements, multiplied by 100). The inter-judge agreement in the classifications was 87.0% for drawing, 62.3% for number writing, and 51.9% for name writing. The inter-judge agreement in the subscales for the coding systems was 70.1% for drawing, 71.4% for number writing, and 75.3% for name writing. Inconsistent judgments were resolved by discussion.

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Insert Table 2, Figure 1a and 1b about here.

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## Results

### Sample-matching task

Figure 2 shows the proportions of correct choice responses for each age group in the S-M task. The scores were computed as the number of correct choice responses divided by the correct number of stimuli for each type of representational system. For the test, a three-way ANOVA (age  $\times$  representational system  $\times$  participants) on the number of correct choice responses was carried out using a transformation ( $\sqrt{x} + \sqrt{x+1}$ ) to obtain this score. The scores were transformed because many zero scores were obtained in the

younger age groups. The analysis revealed significant main effects for age,  $F(3, 53) = 13.30$ ,  $p < .005$ , and representational system,  $F(2, 106) = 9.05$ ,  $p < .005$ , but no significant interaction effect. In a further test for age, there were significant age effects for picture,  $F(3, 53) = 3.52$ ,  $p < .05$ , number,  $F(3, 53) = 6.01$ ,  $p < .01$ , and hiragana letters,  $F(3, 53) = 6.68$ ,  $p < .05$ . Furthermore, in the test for representational systems, there was a significant effect for the 2.5-year-old group,  $F(2, 106) = 3.22$ ,  $p < .05$ , but not for the other age groups. Further analysis showed that the 3- and 3.5-year-olds produced more correct choices than the 2-year-olds for picture, and more correct choices than the 2- and 2.5-year-old groups for number and hiragana letters (Tukey's HSD,  $p < .05$ ;  $p < .10$ ). In the test for age, the picture task produced more correct choices than the hiragana task ( $p < .10$ ). The results indicate that the recognition of representational systems increases with age, with children above 3 years old giving more correct responses than 2-year-old children, and children can understand the similarities within these systems at age 3.

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Insert Figure 2 about here.

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### Production tasks

In the classification system, the products created by children when they were asked to draw were considered drawings. Likewise, the products created when they were asked to produce their name or a number were considered name or number writing. The percentages of the coders' correct recognition scores in the classification are presented in Table 3. For this test, we gave scores 1 and 0 for the correct and the incorrect categorizations of products, respectively. A three-way ANOVA (age  $\times$  representational system  $\times$  participants) was carried out using a transformation ( $\sqrt{x} + \sqrt{x+1}$ ) to obtain this score. The scores were transformed because many zero scores were obtained in the younger age groups. The results showed significant effects for age,  $F(4, 57) = 6.39$ ,  $p < .01$ , and the representational system,  $F(2, 114) = 46.78$ ,  $p < .005$ , but no significant interaction effect. In a further test, there were significant age effects,  $F(4, 57) = 4.70$ ,  $p < .005$  for drawing, and  $F(4, 57) = 2.82$ ,  $p < .05$  for number writing, but no significant age effect for letter writing. Further analysis showed that the 3- and 3.5-year-old groups produced higher percentages of correct recognition than the 2-year olds for drawing (Tukey's HSD, all  $p < .05$ ), and the 3.5-year-olds produced higher percentages than the 2-year-olds for number writing ( $p < .05$ ). Furthermore, in the test for representational systems, there were significant effects for all age groups,  $F(2, 114) = 3.61$ ,  $p < .05$  for the 1.5-year,  $F(2, 114) = 6.55$ ,  $p < .005$  for the 2-year,  $F(2, 114) = 6.37$ ,  $p < .005$  for the 2.5-year,  $F(2, 114) = 13.03$ ,  $p < .005$  for the 3-year, and  $F(2, 114) = 13.03$ ,  $p < .005$  for

the 3.5-year-old groups. In addition, drawing yielded significantly higher percentages of correct recognition than number writing for the 2-, 2.5-, 3-, and 3.5 year-old groups ( $p < .05$ ,  $p < .05$ ,  $p < .01$ ,  $p < .01$ ), and letter writing for 1.5, 2-, 2.5-, 3-, and 3.5-year-old groups ( $p < .10$ ,  $p < .05$ ,  $p < .05$ ,  $p < .01$ ,  $p < .01$ ). These findings indicate that the drawing products were easy for the coders to classify correctly as drawings, even if they were drawings produced by the younger children, while the name or number products were difficult to classify and to distinguish from each other and from the drawings.

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Insert Table 3 about here.

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For the analyses using the coding system, as stated earlier, we reduced the coded results to three representational phases. Table 4 presents the numbers and percentages of participants that were coded into each category (representational phase) with age. For the statistical test, we assigned a one- to three-point score to the results of the representational phases according to the developmental order. A three-way ANOVA (age  $\times$  representational system  $\times$  participants) was carried out. The results showed significant effects for age,  $F(4, 57) = 20.85$ ,  $p < .005$ , the representational system,  $F(2, 141) = 32.56$ ,  $p < .005$ , and the interaction,  $F(8, 114) = 3.21$ ,  $p < .01$ . In the test for age effect, there were significant effects for drawing,  $F(4, 57) = 15.31$ ,  $p < .005$ , number,  $F(4, 57) = 7.16$ ,  $p < .005$ , and letter writing,  $F(4, 57) = 2.06$ ,  $p < .10$ . In addition, there were significant differences between the representational systems for the 2.5-year,  $F(2, 114) = 5.54$ ,  $p < .01$ , 3-year,  $F(2, 114) = 20.83$ ,  $p < .005$ , and the 3.5-year-olds,  $F(2, 114) = 17.61$ ,  $p < .005$ . These differences were found between drawing and number or letter writing for the 2.5-year-olds (Tukey's HSD,  $p < .05$ ,  $p < .01$ ), between drawing and number or letter writing ( $p < .01$ ) and between number and letter writing for the 3-year-olds ( $p < .10$ ), and between drawing and number or letter writing for the 3.5-year-olds ( $p < .05$ ,  $p < .01$ ). These findings reveal that representational systems develop gradually into higher phases with age, but drawing develops faster than number or letter writing, and number writing develops a little faster than letter writing, which was especially obvious at 3.5 years.

Furthermore, in examining whether the products the children created differed in the marks used for each system, it was found that children whose products were scored as representational phase 2 produced different marks for different systems beginning when they were 2 years old. The difference between drawing and writing was seen at category 3, and began to be observed in for 2-year-olds, and the difference between number and letter writing was seen at category 7, and was observed for some for 2- and 2.5-year-olds.

In addition, it must be mentioned that while all the children in the drawing task

produced something, many younger children in the number or letter task did not produce anything; they said they could not write or shook their head (no response). The percentage of participants showing no response in each system is presented in Table 5. The data showed that even children as young as 1.5, 2, and 2.5 could draw, whereas they could not produce their name or a number. Thus, these children were able to differentiate whether they could draw or write, even if they could not produce the writing.

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Insert Tables 4 and 5 about here.

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### **Relationships between the tasks**

Partial correlations (Pearson's correlation coefficient) were computed with the age fixed, to examine the relationships between the tasks. We found no significant correlations between the S-M tasks and the corresponding P tasks, but there were significant correlations between drawing and number writing,  $r = .61$ ,  $p < .05$ , and a trend towards a correlation between number and name writing,  $r = .43$ ,  $p < .10$ . The results show that the recognition of representational systems is not related to the productive activities, but relations between the productive activities are partially significant.

To analyze the naming abilities, they were scored as follows: 0, unable to read; 1, able to read only one number or letter; 2, able to read two or more numbers or letters. The mean scores for each group with increasing age were .53 (SD, .83), .14 (.54), 1.5 (.76), and 1.21 (.98) for numbers, and .00, .00, .00, .14 (.36), and .43 (.76) for letters. The results showed that the children read numbers sooner than letters. A one-way ANOVA (age) was carried out separately with numbers and letters. The results showed a significant effect for age on numbers,  $F(4, 57) = 8.36$ ,  $p < .01$  and on letters,  $F(4, 57) = 2.85$ ,  $p < .05$ . Differences in numbers were found between the 3.5- and the 2-, and 2.5-year-olds (Tukey's HSD,  $p < .10$ ,  $p < .05$ ), and between the 3- and the 1.5-, 2-, and 2.5-year-olds ( $p < .05$ ). Differences in letters were found between the 3.5- and the 2-, and 2.5-year-olds ( $p < .10$ ,  $p < .05$ ). The results of the partial correlations with the age fixed showed significant correlations between the ability to read numbers and the number S-M task ( $r = .51$ ,  $p < .05$ ), and the ability to read letters and name writing in the P task ( $r = .37$ ,  $p < .05$ ), but no significant correlation was found between the ability to read and other tasks.

### **Discussion**

This study investigated the processes by which representational activities emerge with age, to elucidate the relationships and distinctions among the systems. The results of

the P tasks revealed that children developed representational activities through several phases with age and began to use different marks to represent them from the time they were 2 years old. The findings seem to indicate that even children as young as 2 could produce representational marks from distinct systems. However, the results also showed that children younger than 2 produced scribbles or figures for each system, and after that, they produced distinct marks. On the distinction between systems, Levin and Bus reported that children up to age 3 draw and write indistinguishably by making scribbles or producing figures. Although our results are not consistent with Levin and Bus's with respect to age, they seem to coincide with their view that drawing and writing emerge from a common core of indistinguishable graphic products. Accordingly, it seems that our results lead us to the same conclusion as Levin and Bus's. However, before we draw such a conclusion, we need to consider the non-responses in the name- or number-writing tasks, as compared with the drawing task. Our results indicated that the children often drew when they were asked to draw, whereas they could not produce a written product when they were asked to write a number or their name. This finding suggests that even very young children may have some primitive understanding about the distinction between systems and know whether or not they can draw or produce a requested mark.

Thus, there may be several levels to the understanding or knowledge of representational systems, and the early levels need to be analyzed in more detail in future studies, even though researchers have already proposed the developmental stages of writing or notational knowledge (Karmiloff-Smith, 1992; Tolchinsky-Landsmann, 2003 et al.). Moreover, when we discuss the marks produced by children younger than 2, we need to keep in mind that they still lack the motor skill and control to produce various marks well (Yamagata, 2000). Although our results for younger children seem to be consistent with the view that a common core is graphic production, it is unsuitable to assert this view strongly until the effect of motor development on performance can be determined. In addition to these issues, when we deal with the results, we must also pay attention to the kinds of tasks and procedures used in the study, because researchers have used different tasks or methods, such as the card choice task, production task, and others. The difference between the ages of the participants in our study and Levin and Bus's may thus account for the difference in tasks used. Further studies are therefore needed to explore the effects of motor development and the kinds of tasks on performance, and the relationship between understanding and performance.

With regard to the development of representational systems, as expected, this study found that drawing preceded name or number writing in both the classification and P tasks and that number production developed a little faster than letter writing. Although

the developmental rates were different among the systems, this study showed clearly that the developmental process for each system proceeded through common phases, which were identifiable even though the pseudo-products compared had different features in the different systems. Thus, it appears that although children produce drawing and writing domain-specifically, on the whole representational activity as a symbolic system develops domain-generally. In addition, our findings indicate that the pseudo-products for each system have universal features regardless of language, although Saito (1997) revealed that Japanese children over the age of 4 come to understand the features characteristic of the Japanese notation system, which lacks the element-string constraint.

The S-M task revealed that children over 3 could recognize each system correctly, and our correlation results indicated that this recognition was not related to early representational activity. This finding may be partly owing to the procedure of the S-M task itself: the task may be difficult for young children because there was only one sample presentation; therefore, the procedure needs to be reexamined. With regard to reading ability, number reading correlated with the S-M task and letter reading with the P task. These results may be interpreted as follows: it is reasonable to obtain a significant correlation between number reading and the S-M task because it is easy to recognize numbers from the limited set. On the other hand, as it is difficult to recognize letters from among the many letters in a S-M task, and we would not expect to obtain a significant correlation between letter reading and the S-M task. However, it may be easy for children to produce their name after they begin to read letters.

Finally, in studies exploring the developmental processes of representational systems during early development, it is presumed that factors such as a print-rich environment, informal instruction, or reading ability have some effect on the emergence of representational systems (Clay, 1985; Neuman & Dickinson, 2002; Nunes & Bryant, 2004; Whitehurst & Lonigan, 1998 et al.). We need to clarify how these factors are related to the early development and distinction of representational systems and to build a more elaborate model for representational development in future studies.

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Figure Captions

Figure 1a. Examples of drawings in each category.

Figure 1b. Examples of number and name writings in each category.

Figure 2. The proportions of correct choices in the sample-matching task.

# Differential Emergence of Representational Systems:


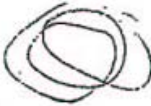



Representational system	Examples
Drawing	
1. Scribbles	S.H.1:11 
2. Marks or scrolled ~	D.T.2:5 
3. A drawing with large~	O.T.2:7 
4. A figure drawing including ~	N.O.2:0 
5. A figure drawing ~	K.S.2:6 

Figure 1 a

# Differential Emergence of Representational Systems:

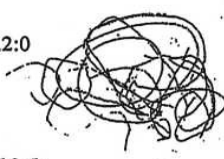





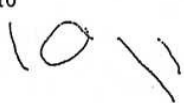


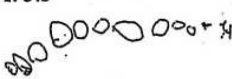
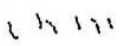



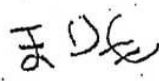
Representational system	Example	Representational system	Example
Number	Name		
1. Scribbles	S.M.2:0 	1. Scribbles	Y.N.2:5 
2. Marks or ~	H.H.2:5 	2. Marks or ~	M.A.2:3 
3. Linearity	Y.2:6 	3. Linearity	D.T.2:5 
4. Segmentation ~	M.H.2:10 	4. Segmentation ~	H.E.3:6 
5. Linearity and ~		5. Linearity and ~	S.K.3:8 
6. Units	K.T. 3:5 	6. Units	S.S.3:9 
7. Verticality	H.A.3:1 	7. Complex writing~	LM.3:4 
8. Conventional number	S.K. 3:8 	8. Conventional writing	LM.3:10 

Figure 1b

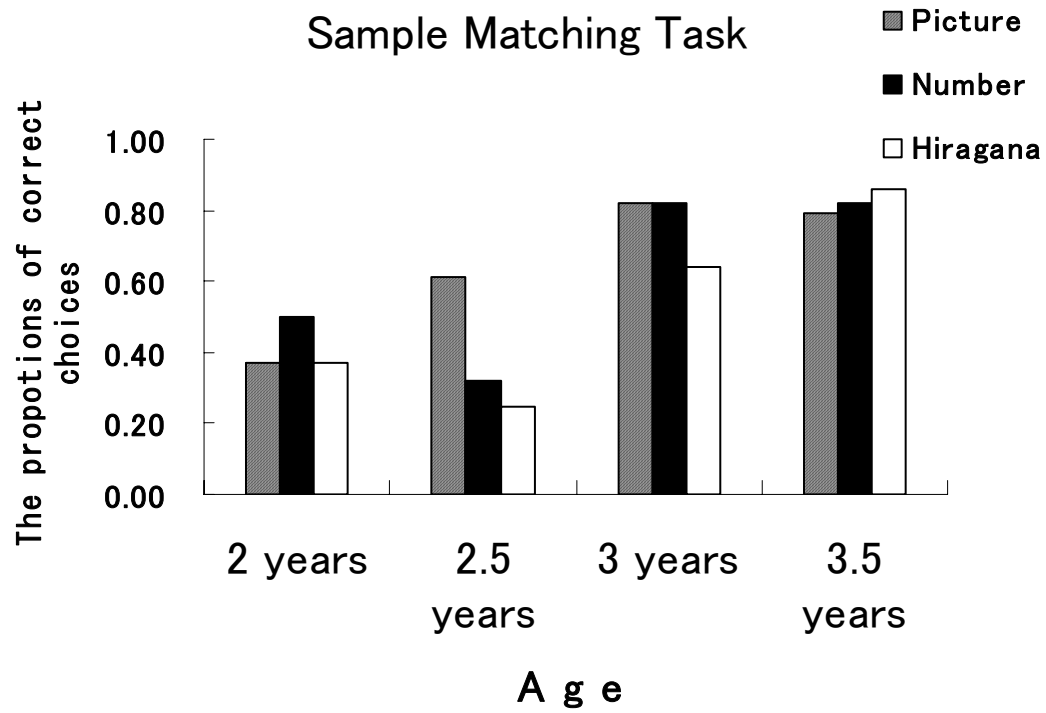


Figure 2

Table 1. Examples of stimuli lists used in sample-matching task.

Lists	1	2	3	4
Picture	ships	airplane	flowers	birds
	insect	fruits	houses	butterfly
Number	739	193	914	385
	502	467	563	270
Hiragana	もみじ	すずめ	くじら	さくら
	とんぼ	つばき	かえで	あさひ
Sign	%&≠	¥ ¢ @	§ ∞ *	& ※ \$

**Table 2. Description of coding system in representational systems.**

System	Categories	Features
Drawing		
Graphic products	1	Scribbles
	2	Marks like scrolled circles or circle-like form
Drawing-like products	3	A large and small line drawing including elements like circles,
	4	A figure drawing including the contour of head, with eyes,
Conventional products	5	A figure drawing including the contour of a head, with features in addition to the eyes, such as the nose, mouth, and others.
Number writing		
Graphic products	1	Scribbles
	2	Marks or form like scrolled circles or circle-like form
Writing-like products	3	Linearity: line drawing produced by horizontal, vertical or curved line.
	4	Segmentation into units: it is composed of such separate units as small circles (no linearity).
	5	Linearity and segmentation into units: linear line going up and down repetitively (wavy line).
	6	Units: simple units repeated.
Conventional products	7	Verticality
	8	Conventional number writing
Name (Letter) writing		
Graphic products	1	Scribbles
	2	Marks or form like scrolled circles or circle-like form
Writing-like products	3	Linearity: line drawing produced by horizontal, vertical or curved line.
	4	Segmentation into units: it is composed of such separate units as small circles (no linearity).
	5	Linearity and segmentation into units: linear line going up and down repetitively (wavy line).
	6	Units: simple units repeated.
Conventional products	7	Complex writing-like products
	8	Conventional name writing



**Table 3.** Percentages of correct responses in the classification.

Age group	1.5	2	2.5	3	3.5
Drawing	60.0	53.3	85.7	92.9	100.0
Writing number	0.0	0.0	14.3	28.6	35.7
Writing letters	0.0	20.0	21.4	21.4	21.4

Table 4. Numbers and percentages of participants categorized into each category and representational phase in the production task.

Age	1.5	2.0	2.5	3.0	3.5		1.5	2.0	2.5	3.0	3.5	
Category						Representational phase						
Drawing												
1	3	5	1	0	0	1.	5(100.0)	10(66.7)	3(21.4)	1( 7.1)	0	
2	2	5	2	1	0							
3	0	4	3	1	0		2.	0	5(33.3)	6(42.9)	1( 7.1)	1(7.1)
4	0	1	3	0	1							
5	0	0	5	12	13	3.	0	0	5(35.7)	12(85.7)	13(92.9)	
Number												
1	5	11	6	3	1	1.	5(100.0)	13(86.7)	6(42.9)	6(42.9)	1(7.1)	
2	0	2	0	3	0							
3	0	0	2	0	1		2.	0	1(6.7)	5(35.7)	3(21.4)	5(35.7)
4	0	0	1	1	1							
5	0	0	0	0	0							
6	0	1	1	1	1							
7	0	0	1	1	2							
8	0	1	3	5	8	3.	0	1(6.7)	3(21.4)	5(35.7)	8(57.1)	
Hiragana												
1	5	9	4	3	3	1.	5(100.0)	11(73.3)	5(35.7)	4(28.6)	4(28.6)	
2	0	2	1	1	1							
3	0	3	2	3	1		2.	0	4(26.7)	9(64.3)	10(71.4)	9(64.3)
4	0	0	0	0	1							
5	0	0	1	0	2							
6	0	0	3	3	3							
7	0	1	3	4	2							
8	0	0	0	0	1	3.	0	0	0	0	1 (7.1)	

Table 5. Percentages of participants producing no response  
in the production task.

Age group	1.5	2	2.5	3	3.5
Drawing	20.0	0.0	0.0	0.0	0.0
Number writing	100.0	60.0	35.7	21.4	7.0
Letter writing	60.0	26.7	14.3	14.3	14.3